2006 PROGRESS REPORT for SSP03R603

Riparian Willow Restoration along the Illinois River at Arapaho National Wildlife Refuge, Colorado

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BACKGROUND

Riparian willow communities along the Illinois River at Arapaho National Wildlife Refuge (NWR) provide important habitat for a number of wildlife species, including neotropical migratory birds. Existing stands are sparse and discontinuous throughout much of the Refuge and appear overaged, with little natural regeneration. Likely causes include historical clearing; low beaver populations with minimal influence of beaver dams on bottomland hydraulics; reduced streamflow from water diversion; channel incision, perhaps related to diminished sediment supply; possible climatic shifts; and high levels of herbivory from wintering elk, cattle, and introduced moose.

The United States Fish and Wildlife Service (FWS) Comprehensive Conservation Plan for Arapaho includes the goal to

> *Provide a riparian community representative of the historic flora and fauna in a high valley of the central Rocky Mountains to provide habitat for migratory birds, large mammals, and river dependent species.*

The plan further specifies the objective to

> *Restore 50 to 100 acres of dense (40–100 percent canopy closure) willow in patches >0.2 ha and >10 m wide in the central third of the Illinois River (from the north end of the island to the confluence with Spring Creek) to connect existing willow patches and maintain 535 acres of dense willow in patches in the lower third of the Illinois River to benefit neotropical migrant songbirds (yellow warbler, willow flycatcher) and resident moose and beaver.*

The overall goal of our study is to inform these restoration activities by quantifying the effects of alternative management actions on riparian willow communities in order to provide the Refuge with a set of management tools with known effectiveness under different circumstances. The work is structured as adaptive management: hypothesizing feasible and effective management actions, implementing those actions, measuring responses, and iteratively revising management actions. The study has focused on two major components:

1. A **core exclosure experiment** focused on measuring the effect of herbivory on willows with moisture (depth to water) as a co-variate; and
2. A series of **restoration tests** designed to identify efficient restoration procedures and constraints on such actions.

Because of funding limitations we have de-emphasized contextual analyses to clarify the status and dynamics of willow in the valley as a whole and how willow communities on the Refuge.

CORE EXCLOSURE EXPERIMENT

Paired exclosure and control plots at five locations were established in the northern portion of the Refuge in 2003. They were initially sampled for willow cover by species and height class at the end of the growing season in 2003. We plan a complete resampling for the herbivory release experiment in August–September 2007, which will encompass 4 winters (when most herbivory occurs) and 4 growing seasons. Incidental observations of individual plants suggest that the

exclosures are beginning to produce greater net shoot growth, especially height growth of suppressed individuals initially less than 1.5 m tall.

We installed staff gages and recorded water levels at the staff gages and wells (5/site) at roughly 2-week intervals from May–October in both 2004 and 2005. Results of this monitoring indicated a relatively flat, near-channel groundwater surface that closely tracked streamwater surface elevation. After considering these results along with maintenance difficulties with the in-channel staff gages and the cost of frequent direct measurements of wells, we shifted our approach in 2006 to using recording pressure transducers in the well closest to the channel and the well farthest from the channel at each site (2/site = 10 total). We have begun, but have not completed, detailed topographic surveying at each site.

In 2005 high early summer discharge with overbank flooding produced water depths of about 10 cm over most of the permanent exclosure-control sites. Stream water levels in 2004 and 2006 were near bankfull, but did not have overbank flooding. Low water for both stream and near-channel groundwater occurred in late August and early September in 2004, 2005, and 2006, with depths to groundwater of 1.0 to 1.5 m throughout most of the 5 permanent exclosure-control sites.

RESTORATION TESTS

Testing is being done at several levels including a series of specific, replicated experiments and at higher levels gaining experience with different equipment and administrative arrangements that might be employed in broader-scale restoration. Given budget realities, extensive restoration actions at the Refuge will likely depend heavily on volunteers working over many years. A three-way Memorandum of Understanding and cooperative relationship among the United States Geological Survey (USGS), FWS, and the non-profit Wildlands Restoration Volunteers (WRV) has facilitated the use of volunteers to implement willow planting and fencing. Results to date from these experiments are described below.

2004 *S. lasiandra* plantings. The WRV provided more than 40 volunteers for the main planting weekend in late May, harvesting freshly cut poles and doing the planting. The 2004 quantitative experiment used *Salix lasiandra* (whiplash willow) pole cuttings. *S. lasiandra* is the largest of the common willows at Arapaho NWR. One quarter of each of the 10 permanent site pairs (both exclosure and control) was used for the manipulations. Each manipulation subplot was divided into 3 zones: terrace or upland, near-bank (within 10 meters of bankfull lip), and channel (below bankfull lip). Two kinds of *S. lasiandra* poles were used as a plant-type treatment: (a) fresh-cut in late May at the time of planting, about 2 weeks after bud-break; and (b) pre-cut about 2 weeks before bud-break. The pre-cut poles were stored in a snowbank at a Colorado State Forest facility in the mountains. Eight individuals of each type of pole were placed in 1-m holes excavated with a 6-inch auger mounted on a tracked Bobcat (T190) in the terrace and near-bank zones. In the channel zone, 8 bundles of each type of willow poles (3 poles/bundle) were staked in vertical trenches dug into the side of the bank.

Almost all of the planted material vigorously leafed out within the first month. There was substantial die-back in the drier late-August period of the first year. Overall survivorship at the end of the second growing season (September 2005 for May 2004 plantings) was about 12 percent, with an average longest-leader length of survivors of 41 cm. At the end of the third growing season overall survivorship was 4 percent with an average longest-leader length of survivors of 58 cm (maximum of 165 cm). There were no appreciable differences between poles harvested pre-bud break and those freshly harvested at time of planting shortly after bud break. However, survivorship after three growing seasons was substantially higher in the exclosures (7 percent) than in the controls (1.6 percent).

2005 *S. exigua* and *S. geyeriana* plantings. The WRV provided 50 volunteers the weekend of June 4, 2005. Unfortunately, no work was completed because the bottomland was inaccessible

due to overbank flooding and heavy snowfall on June 4. In late June, USGS conducted a limited pole planting of freshly harvested *Salix exigua* and *S. geyeriana* at 4 off-channel depression sites. We used a hydraulic "stinger" constructed from ¾-in pipe and powered by a portable pump using streamwater to hydraulically "drill" a narrow 1-m deep hole for each pole. At the end of the first growing season (September 2005), survivorship was 28 percent for *S. exigua* and 15 percent for *S. geyeriana.* Average leader lengths of survivors were 9.7 cm for *S. exigua* and 4 cm for *S. geyeriana.* None of these plantings survived through the second growing season (September 2006 for June 2005 plantings).

2006 *S. monticola* and mixed plantings. WRV provided 60 volunteers the weekend of May 20, 2006. Based on observations of root-sprout sapling growth of planted *Populus angustifolia* in small fenced woodlots, we constructed 4 small exclosures in off-channel depressions associated with relict channels. Our hypothesis was that low-cost, standard cattle fencing might sufficiently reduce herbivory to allow growth above the browse line if employed in small blocks that could be avoided easily by moving animals. Using off-channel depressions with existing suppressed willow provides (a) an opportunity for release of existing plants, (b) a protected site for plantings, and (c) lower flood-related fence maintenance costs. We planted 30 poles of *S. monticola* within and nearby (control) each of these exclosures as well as at an unexclosed, beaver-pond bank site. These poles were harvested 3–4 days before planting, soaked in the river, planted in 1-m holes created with a generator-powered hammer drill with long bit, and amended with a commercial rooting supplement. Volunteers also planted a larger number of mixed species poles at these sites using a mixture of hammer drill, 2-person power post-hole auger, hydraulic "stinger," and metal spikes to create holes from 0.3 to 1.0 m deep. We also measured sizes of existing *S. geyeriana* (which were generally less than 1 m tall) within and outside these exclosures to begin quantification of a release response.

Survivorship of the *S. monticola* poles at the end of the first growing season (September 2006 for May 2006 plantings) was 93 percent in the exclosures, 97 percent in the nearby control areas, and 80 percent in the beaver-pond bank area. Average leader length of survivors was 22 cm in the exclosures, 15 cm in the nearby control areas, and 15 cm in the beaver-pond bank area. We found somewhat lower first-growing-season survivorship of 68 percent and average leader length of survivors of 18 cm in a sample of the mixed-species, mixed-method plantings in the exclosures.

DISCUSSION

Operational experience. The volunteer arrangement has worked well for those aspects of the overall project that are labor-intensive and do not require a sequence of actions over multiple days or weeks. There are some administrative costs associated with organizing and supporting 40–60 people and some timing constraints and risks, especially in the case of inclement weather as we experienced in 2005.

The tracked Bobcat (T190) with 6-in auger, hydraulic "stinger," generator-powered hammer drill with long bit, and 2-person gasoline-powered post-hole auger were all practical and effective for 1-m pole planting. The Bobcat (a) had rental costs, (b) required a trailer towed by a heavy-duty pickup to get close to the sites, (c) required at least a semi-skilled operator, and (d) required hand-filling of augured holes. The hydraulic "stinger" (a) required close proximity to a legal water source, (b) often left a gap between the walls of the narrow hole and the planted stem, and (c) was awkward to move any substantial distance along the bank. The generator-powered hammer drill (a) had some rental or capital costs, including a specialized long bit; (b) required moving a relatively awkward and heavy generator; and (c) was very fast per hole. The 2-person gasoline-powered auger was relatively slow and awkward to use although it was possible to access a wider set of locations with two people hand-carrying it. Creating a hole by pushing in and removing a metal spike is very fast in moist ground, but is effectively restricted to shallow depths of less than 0.5 m.

Herbivory release. Ungulate herbivory is suppressing existing small willow and influencing the success with planted material. Maintaining the permanent exclosures to track willow stand response over decades remains our highest study priority. We plan to resample the exclosures and controls at the end of the 2007 growing season to quantify the strength of willow stand response to release from ungulate herbivory. We are also tracking both release of small individuals and success of planted material in the more temporary exclosures constructed in off-channel depressions. Fence maintenance at channel crossings has been a major problem and is probably not feasible for any extensive use. Thus, the off-channel depressions appear to offer a desirable alternative for both fencing-based release of existing suppressed willow and protection of planted material. Observations following the winter of 2006–2007 will provide an initial indication of the effectiveness of the low-cost, easily removable cattle-style fencing in reducing elk herbivory in small patches.

Plantings. The simple, "it-should-work-okay'" pole plantings have had low survivorship into the second and third growing seasons. Likely reasons include the following:

1. *Plant material.* Cuttings work best when obtained as vigorously growing stems from vigorously growing plants. In 2004 and 2005 we harvested local material largely from impoundment dikes that require occasional clearing for dike maintenance. Some of this material was not ideal for pole planting, the harvest and planting times were late in 2005, and the *S. monticola* used in 2006 may be a more suitable species to use than the *S. geyeriana*, *S. lasiandra*, or *S. exigua* used in 2004 and 2005.

2. *Physical conditions.* Late summer water depths and a 1.0 to 1.5-m decline in water levels from June to August are not ideal; while they are within the range of tolerance for adults with established root systems, they may not be acceptable for bare cuttings establishing a new root system. Lack of good soil contact with the pole throughout the length of the hole has been a problem, especially with the hydraulic stinger that fills the hole with water under pressure. More attention to tamping and back-filling with a wet slurry seems to have reduced these problems in 2006.

If the high first-year survivorship of the 2006 *S. monticola* pole plantings translates into good second- and third-year survivorship, using a generator-powered hammer drill, carefully selecting recently harvested material, and carefully backfilling in off-channel depressions may be the most feasible approach for getting large numbers of saplings established using a "pulsed" workforce of volunteers. The alternative is to explore use of pre-rooted plants, either freshly excavated root-ball saplings or containerized cuttings that have been grown in a greenhouse. We have avoided this approach because (a) they are difficult to plant as deeply as the August–September 1-m depth to groundwater, and (b) much of the cost and effort is spread over months, requiring greenhouse space and work, and thus is difficult to implement with volunteers. However, a small-scale experiment with containerized, pre-rooted material may be useful to suggest whether this approach would work fundamentally better than the relatively large number of pole plantings that appear to be necessary to produce a reasonable density of surviving saplings.